Cereal production systems in North America: Challenges for effective adaptation

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Cereal Crops and Climate Change

Ensuring Future Supplies
World Distribution of Cereals

Where is the Wheat?

Map showing the distribution of high and moderate wheat yields around the world. The map highlights regions with high wheat yield in Europe, North America, and parts of Asia. The map uses different shades to indicate varying levels of wheat yield. The sources are mentioned as Geography in the News 9/9/11 and Goode's World Atlas, 20th ed., by M. Shears.
United States Production
Wheat Production United States

![Graph showing wheat yield (kg ha⁻¹) and area (ha) over the years from 1950 to 2020.](image)

- **Yearly Area (ha):**
  - 1950: 1.6e+7
  - 1960: 1.8e+7
  - 1970: 2.0e+7
  - 1980: 2.2e+7
  - 1990: 2.4e+7
  - 2000: 2.6e+7
  - 2010: 2.8e+7
  - 2020: 3.0e+7

- **Planted Area (ha) vs. Harvested Area (ha):**

- **Yield (kg ha⁻¹):**
  - 1950: 500
  - 1960: 1000
  - 1970: 1500
  - 1980: 2000
  - 1990: 2500
  - 2000: 3000
  - 2020: 3500
Residual Yields

Residual Yield (kg ha\(^{-1}\))

US Wheat Production

Year
Canada Wheat Production

Wheat Production Canada

Year


Yield (kg ha\(^{-1}\))

500 1000 1500 2000 2500 3000 3500 4000
Wheat Production Mexico

![Graph showing wheat production yield in Mexico from 1960 to 2020. The yield increases over time, with fluctuations. The x-axis represents the year, and the y-axis represents yield in kg ha\(^{-1}\).](image1)

![Graph showing wheat production area in Mexico from 1960 to 2020. The area harvested increases over time, with fluctuations. The x-axis represents the year, and the y-axis represents area in ha.](image2)
Wheat Yield Increases

- Mexico – 59.30 kg ha\(^{-1}\) yr\(^{-1}\)
- Canada – 27.87 kg ha\(^{-1}\) yr\(^{-1}\)
- United States – 28.03 kg ha\(^{-1}\) yr\(^{-1}\)
Climate Impacts

• Temperature
  – Heat
  – Frost

• Precipitation
  – Spring vs Fall
Oklahoma

Wheat Production Oklahoma

Yield (kg ha\(^{-1}\))

Area (ha)

Year
South Dakota

Wheat Production South Dakota

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield (kg ha(^{-1}))</th>
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<tbody>
<tr>
<td>1960</td>
<td>1000</td>
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<tr>
<td>1970</td>
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<tr>
<td>2010</td>
<td>6000</td>
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<tr>
<td>2020</td>
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Wheat Production South Dakota

<table>
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<th>Year</th>
<th>Area (ha)</th>
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<tr>
<td>1920</td>
<td>1e+6</td>
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<tr>
<td>1940</td>
<td>2e+6</td>
</tr>
<tr>
<td>1960</td>
<td>3e+6</td>
</tr>
<tr>
<td>1980</td>
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<td>2000</td>
<td>5e+6</td>
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<tr>
<td>2020</td>
<td>6e+6</td>
</tr>
</tbody>
</table>

Plotted data show trends in yield and area from 1920 to 2020.
Washington

Wheat Production Washington

Yield (kg ha\(^{-1}\))

Area (ha)

Planted Area (ha)

Harvested Area (ha)

Year


6.0e+5 8.0e+5 1.0e+6 1.2e+6 1.4e+6 1.6e+6

1920 1940 1960 1980 2000 2020

1.2e+6 1.4e+6 1.6e+6 1.8e+6 2.0e+6 2.2e+6

1.2e+6 1.4e+6 1.6e+6 1.8e+6 2.0e+6 2.2e+6
California

Wheat Production California

Year

Area (ha)

Yield (kg ha\(^{-1}\))


0 1000 2000 3000 4000 5000 6000 7000

Planted Area (ha)

 Harvested Area (ha)

1920 1940 1960 1980 2000 2020

0 1e+5 2e+5 3e+5 4e+5 5e+5 6e+5
Observations

• Southern portion of the wheat belt is showing yield declines since 1990
• Yield increases are occurring in more northern latitudes of the wheat belt
• Combination of factors primarily related to temperature
Temperature Impacts

Prasad and Djanaguiraman, 2014
Temperature Impacts

Prasad and Djanaguiraman, 2014
Kansas Wheat Yield Analysis

Tack et al. 2015 PNAS
Changing Climate

Temperature Increase
Yield Decrease
Yield Increase

Winter Wheat 2014
Planted Acres by County for Selected States

Temperature Increase
Yield Decrease

Acres
- Not Estimated
- 0 - 5,000
- 5,000 - 9,999
- 10,000 - 24,999
- 25,000 - 49,999
- 50,000 - 99,999
- 100,000 +

USDA Agricultural Statistics Service
Implications

• Increasing temperature in the flowering and grain-filling period in the southern wheat belt will continue to decrease yields

• Temperature extremes (frost) and high temperatures (pollination) will affect yield

• Temperature increases bring northern wheat belt into more favorable regime

• Soil water more of a factor in western wheat production areas (CA, OR, WA)
Thank you!

University of Idaho

Washington State University

Oregon State University

USDA

NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Pacific Northwest Farmers Cooperative

Monsanto